Development and Characterization of Fast Burning Solid Fuels/Propellants for Hybrid Rocket Motors with High Volumetric Efficiency

Completed Technology Project (2011 - 2015)

Project Introduction

The objective of this proposed work is to develop several fast burning solid fuels/fuel-rich solid propellants for hybrid rocket motor applications. In the formulation and processing studies, the following factors will be considered: utilization of energetic ingredients with high volumetric heating rates in the fuel matrix, selection of high density and high specific impulse formulations for attaining attractive propulsive performance, selection of fuel composition with favorable mechanical properties and ease of handling and processing. Candidate fuels/fuel-rich propellants will be processed using vacuum casting facilities at the High Pressure Combustion Lab (HPCL) of The Pennsylvania State University. The selected formulations with desirable propulsive performance will be cast into fuel grains to be tested in several hybrid rocket motors for determination of their burning characteristics. Under previous contracts, similar fuel grain processing and evaluation have been conducted at HPCL. Advanced diagnostic systems such as: a real-time X-ray radiography system, an ultrasound pulse-echo system, and a three-color pyrometer system will be utilized in the rocket motor test firings. An existing bi-directional vortex hybrid motor combustor at HPCL will also be used to investigate the degree of further enhancement of fuel-regression rates due to swirl motions of the oxidizer stream for pressures up to 8.4 MPa (1200 psig). Three commonly used oxidizers (gaseous oxygen, 75% hydrogen peroxide, and nitrous oxide) have been used at HPCL for hybrid motor firings. One of them will be selected as the standard oxidizer for comparing the combustion performance of different fuels. A high-speed digital camera can also be incorporated in the vortex hybrid motor to film the in situ regression behavior of a cylindrical fuel grain. In all hybrid motor tests, multiple high-frequency pressure transducers will be installed at different locations for recording pressure-time traces and detecting any combustion instabilities. The anticipated results include: demonstration of the processing feature of various high burning rate solid fuels/propellants, analysis of the hybrid rocket motor firing data to report the combustion behavior of the selected fuel formulations, and demonstration of at least two major solid fuel candidates with highly desirable combustion characteristics for stable burning under realistic hybrid motor operations. The major impact of this project is to show that high regression rate solid fuels/propellants with high volumetric loading density can be achieved in a laboratory scale motor (less than 30 lbs of fuel). Such type of fuel grains can be applied to much larger-scale motors for future space propulsion applications.

Anticipated Benefits

The major impact of this project is to show that high regression rate solid fuels/propellants with high volumetric loading density can be achieved in a laboratory scale motor (less than 30 lbs of fuel). Such type of fuel grains can be applied to much larger-scale motors for future space propulsion

Project Image Development and Characterization of Fast Burning Solid Fuels/Propellants for Hybrid Rocket Motors with High Volumetric Efficiency

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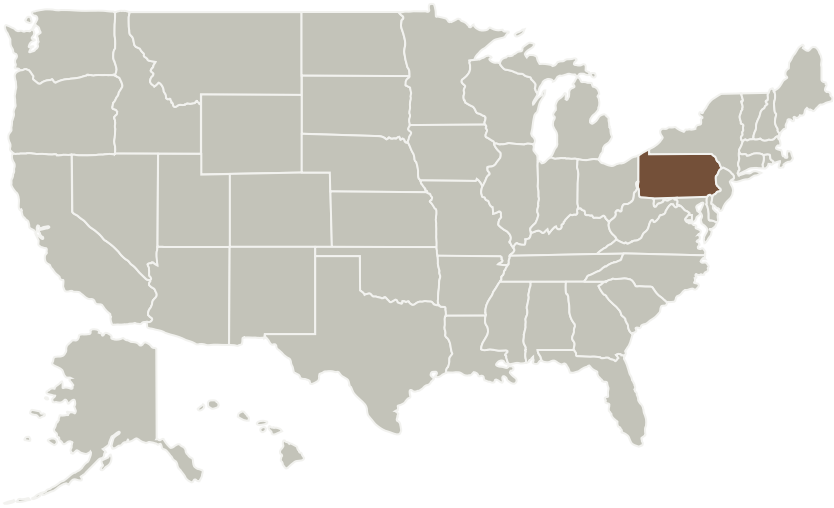
applications.

Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations
Pennsylvania

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

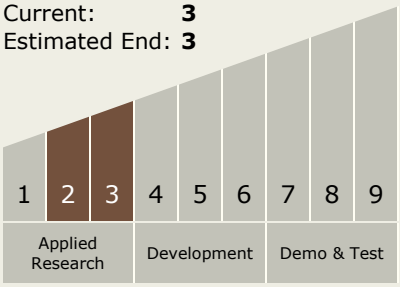
Ken Kuo

Co-Investigator:

Daniel A Larson

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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Images

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Project Image Development and Characterization of Fast Burning Solid Fuels/Propellants for Hybrid Rocket Motors with High Volumetric Efficiency
(https://techport.nasa.gov/image/1848)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.1 Chemical Space Propulsion
    - TX01.1.5 Hybrids